

Developing Irrigation Systems for Sustainable Aquaculture in Vietnam

By

Le Minh Thoa
Thuyloi University, Vietnam
Email: thoalm@tlu.edu.vn

Nguyen Tu Anh
Hanoi University of Natural Resources and Environment, Hanoi, Vietnam
Email: anhnguyen90@hotmail.com

Abstract

The main goal of building irrigation in the Mekong Delta is to serve crops, so the irrigation system cannot meet the needs of aquaculture development. The main feature of aquaculture is that the water supply must be clean and not reuse wastewater from other industries, including the central wastewater of fisheries and agriculture. That said, an irrigation system must distinguish two different water supply sources and drainage. Due to many anti-salt and anti-flood systems, aquaculture has an insufficient water supply and stops the natural fish flow. When farmers produce goods depending on the product consumption market, the requirements of the irrigation system must also be gently changed according to the farming needs of the people. The sweet border areas must be the irrigation system. It can supply fresh water for rice cultivation and saltwater for aquaculture in a specified time.

Keywords: Irrigation system, fisheries, sustainable development

Introduction

In the context of climate change and the implementation of economic restructuring, it is required that irrigation work is a fundamental and sustainable innovation to maximize the potential and advantages of the irrigation system to meet the needs of the community. Meet the requirements to ensure national water source security, protect agricultural production activities, and serve people's daily lives. The fishery industry development strategy for 2030, with a vision to 2045 in Decision No. 339/QĐ-TTg of the Prime Minister, has determined to take advantage of the potential of water surface and develop aquaculture on reservoirs to promote natural potential and create livelihoods for ethnic minorities in remote areas. The Ministry of Agriculture and Rural Development has approved the national plan to develop seafood processing until 2020. Accordingly, by 2020, the output of processed seafood for export will be about 2 million tons with a growth rate. About 3.5% on average, and export turnover reached 10 billion USD with an average growth rate of over 7% per year. The output of processed seafood for domestic consumption reached 950 thousand tons, an average growth of 3.3 %/year. The value of processing for domestic consumption grew by an average of 5.8% per year. The total capacity of industrial-scale seafood processing reaches 2.13 million tons of products per year, and the cold storage system has a capacity of 1.1 million tons. The full power of industrial-scale seafood processing goes 2.13 million tons of products/per year. The cold storage system has a total of 1.1 million tons. The proportion of value-added products reaches 60-70% of the volume of processed products. The renewal rate of processing machines and equipment goes 12-15 %/per year. 100% of seafood processing facilities ensure food hygiene and safety.

Published/ publié in *Res Militaris* (resmilitaris.net), vol.13, n°2, January Issue 2023

1.1. Irrigation system for aquaculture

Consumption of more water: this means that all construction items must have a larger aperture, a larger channel cross-section, and a wider culvert aperture (generally, it must be replaced with a new bridge to meet the demand because the culvert or Bridges with fisheries not only allow water to flow through, but also allow larvae and eggs to pass, and the task of flood control is not necessary for aquatic products). Due to the construction of many sluices, it has limited water traffic, but the characteristics of seafood consumption need a lot of water traffic (consumption of pangasius, basa)

Aquatic wastewater will be a good water source for agriculture. In contrast, agricultural wastewater cannot be supplied to aquatic products: this feature means that there must be a separate water supply and drainage system. With the current irrigation system in the Mekong Delta being a closed network of rivers and canals sharing the same system, it isn't easy to have two separate water sources. However, with the dilution capacity of large rivers, these rivers can be a common source of water supply and drainage, while with a canal system of grade 2 or lower, a separate system is required.

Agriculture must fight floods, but the more flood-prone fisheries, the better. Floodwater for aquatic products is an inexhaustible source of resources. To avoid overflowing the bank, use a net to raise the bank to ensure no loss of fishery products.

Sweetening is good for agriculture but is only sometimes suitable for fisheries. Because there are sluices to prevent salinity, it is not possible to guarantee the amount of water and especially aquatic species that do not flow through the channel. Even more interesting is that when people produce goods according to the market, what do they need to raise effectively? They want to raise black tiger shrimp. However, they need salt water to grow (but still have to follow the planning and ensure enough water to feed them sustainability).

2. Achievements in Irrigation Systems in Aquaculture

2.1. Irrigation work has contributed to serving production and people's livelihood, ensuring food security, and contributing to environmental protection and natural disaster prevention and control.

a) Our country has a relatively developed irrigation system, essential to increasing the cultivated area, increasing the crop season, improving the soil, and ensuring food security and export.

Vietnam is one of the few countries in Southeast Asia with a relatively complete developed irrigation system, with thousands of large, medium, and minor irrigation systems for water supply, irrigation, and drainage serving agricultural production, aquaculture, and water supply for domestic and industrial use, preventing floods, inundation, and drought, and contributing to environmental protection. According to statistics of the General Department of Water Resources, as of 2014, the country has built 6,648 reservoirs of all kinds, about 10,000 sizeable electric pumping stations, 5,500 large irrigation sluices, 234,000 km of canals and 25,960 km of dikes of all kinds. Of these, there are 904 irrigation systems for 200 ha or more irrigation. In addition, more than 755,000 small and medium pumps are purchased by cooperatives and farmers.

The total area of irrigated rice cultivation is over 7.3 million hectares. The Winter-Spring crop area is 2.99 million hectares, the Summer-Autumn yield is 2.05 million hectares, and Season is 2.02 million hectares. In addition, irrigation systems also irrigate 1.5 million

hectares of vegetables and industrial plants; create water sources for 1.3 million hectares of arable land; provide about 6 billion m³ of water for domestic and industrial use; salinity prevention for 0.87 million ha; improve 1.6 million hectares of alum and drain water for over 1.72 million hectares of agricultural land. Irrigation works systems have supported and facilitated the development of crop diversification and restructuring in agriculture. Our country's agriculture has gradually formed specialized farming production areas, shifting progressively from self-sufficiency and self-sufficiency to large-scale commodity agricultural production; typically, the two critical areas of our country's rice are the rice fields. The Mekong Delta and the Red River Delta specialize in coffee, rubber, and tea for export, etc.

b) The system of irrigation works has made an essential contribution to natural disaster prevention and control, such as: preventing and combating inundation and inundation for urban and rural areas, drought, and saltwater intrusion. The country has built about 6,150 km of river dykes, and 2500 km of sea dykes; a system of reservoirs nationwide, including many large pools (Cua Dat, Ta Trach, Dau Tieng, etc.), plays an essential role in flood prevention and control in river basins. The system of large drainage axes and large-scale electric pumping stations has been invested in and built to ensure against flooding and waterlogging in urban areas, industrial parks, and rural residential areas.

The agricultural production achievements during the doi moi period are an essential basis for the recent Party Congresses to emphasize the critical role of agricultural and rural industrialization and modernization because it generates money. Topic and a solid foundation to promote the entire process of industrialization and modernization of the country's economy.

c) The irrigation system has contributed to ensuring water sources for daily-life water supply, water environment protection, service development, and tourism development for regions across the country.

2.2. The irrigation management organization system from the central to local levels is constantly consolidating and perfecting

The state management apparatus for irrigation from the central to local levels is relatively synchronous and unified to perform the state irrigation management.

Regarding the management of sizeable focal irrigation works, inter-commune irrigation systems or more, the whole country currently has 96 organizations managing and exploiting irrigation works, which are enterprises directly under the province, three enterprises under the Ministry of Agriculture and Rural Development. Agriculture and Rural Development, seven provincial non-business units and four part-time Irrigation Sub-Departments. Regarding the management of minor irrigation projects and the system of canals in the field, there are 16,238 water-using organizations nationwide, including the following main types: Cooperatives providing irrigation services (Service cooperatives), Agricultural and irrigation cooperatives), cooperative organizations (Water User Association, Cooperative Group, Irrigation Team), and Irrigation Management Board. Cooperatives and cooperative groups are two main types, accounting for 90% of water users.

The management and exploitation of irrigation works are gradually getting in order, serving healthy production and people's livelihood. Activities of organizations managing and exploiting irrigation work meet the requirements of production and people's daily life.

2.3. Existences and limitations

a) The efficiency of the management and exploitation of irrigation works is still weak

Despite the significant investment, irrigation management still needs to be improved.
Low management efficiency:

Rapid deterioration of buildings, wasteful use of water.

- The weak financial system mainly relies on revenue from the state budget, and the method of distribution and acceptance does not depend on the quality of irrigation and drainage services.
- The organization of grassroots irrigation is not sustainable; the lack of funds for maintenance, repair, and dredging of canals leads to damaged works and rapid deterioration.
- Dam reservoir safety management has not been given due attention; many dams are degraded at risk of unsafety, and reservoir management organization (tiny barriers)

+ Infrastructure is slowly being consolidated:

- The rate of the irrigated area reaches 80%, the rate of water supply for other services is less concerned and effective
- Irrigation infrastructure in the field has not met the requirements of agricultural production according to advanced processes or is challenging to convert when changing crop structure.
- The country has 234,000 km of canals of all kinds, but only 23% have been fortified.

+ Water quality in many systems is not guaranteed, affecting the productivity and quality of agricultural products, especially in the Red River Delta and Mekong River Delta.

b) The irrigation system has not met the requirements of diversified and modern agriculture

+ The scale of agricultural production is still tiny and fragmented:

In recent years, land consolidation and exchange of plots have been carried out in many places to form fields large enough to apply modernized and mechanized production methods. Some localities have conducted many batches of land consolidation and change of plots, such as Thai Binh, which has implemented merger and exchange of schemes twice in 1993 and 2012. Still, now each household has an average of 2 parcels of land.

In general, the smallness and fragmentation of land tend to increase gradually from South to North, from plains to mountainous areas. This situation has shown no significant improvement due to population increase. But agricultural land is decreasing, especially in the two large granaries of the country.

+ The irrigation system has not met the requirements of diversification and modernization in agricultural production:

The current in-field canal systems are mainly earth canals, performing combined irrigation tasks without regulating sluices; the design of plot banks and plots needs to be improved, failing to meet the needs of water retention and prevention. Meanwhile, in many places, crops were converted firmly; vegetables were brought to the rice fields instead of rice. However, our country's current irrigation system must still meet crop diversification requirements and intensive farming to increase crops.

+ The adaptability of irrigation systems to drought and saltwater intrusion is still limited:

According to a Ministry of Agriculture and Rural Development report, from August 2012 to March 2013, drought and saltwater intrusion seriously affected the central provinces and the Central Highlands. In which the South Central region has 17,277 hectares of crops affected by drought and saltwater intrusion (15,627 hectares of rice, 300 hectares of coffee, and 1,350 hectares of other crops); In the Central Highlands, there are 39,964 hectares of crops affected by drought (11,036 hectares of rice; 23,921 hectares of coffee; 5,007 hectares of other crops).

Drought continued to occur in 2014, especially in recent days; droughts occurred in many parts of the country, especially the Central and Central Highlands provinces, causing severe damage. Typically, the damage caused by a deficiency in Ninh Thuan province as of April 20, 2015, in the 2014-2015 winter-spring crop, the area that stopped production due to lack of irrigation water was 6,100ha. 3,214ha of rice and 2,886ha of short-term crops indirectly caused over 30,000 tons of food and other cash crop losses, significantly reducing social products due to the effects of drought. With production in the province, there was 40.4ha of rice with 100% damage, 3.1ha of yield reduction by 30%; 135ha of vegetable crops with 50% yield reduction; 03 ha of fruit trees were lost, and 77 ha are not enough water for irrigation, reducing the yield by 50%; the sugarcane area due to prolonged sun damage is over 1,117 ha; 68ha of corn is 100% damaged.

Besides, in the Central Highlands, drought is also happening very seriously. According to information from the Department of Agriculture and Rural Development, this is the most severe drought in the past ten years; in Dak Lak province alone, as of May 4, 2015, more than 50,000 hectares of crops have been affected due to drought and lack of water for irrigation.

+ Apply water-saving irrigation technology that has not been deployed on a large scale

The system of irrigation works is designed mainly to focus on supplying water to rice plants; most dry crops have yet to be irrigated or irrigated by outdated water-wasting methods.

- According to the "Strategy for the development of agriculture and rural areas of Vietnam to 2020 and a vision to 2030", by 2012, the cultivated area of tea reached 129 thousand hectares, coffee 622.1 thousand hectares, rubber 910, 5 thousand ha, pepper 58.9 thousand ha, cashew nut 235.9 thousand ha, fruit trees 675.9 thousand ha, sugarcane 297.9 thousand ha, vegetables and beans 1,004.9 thousand ha the use of advanced irrigation solutions, saving water is still limited.

+ Investment in irrigation infrastructure for aquaculture is meager; the irrigation system still needs to meet the aquaculture requirements. There is no planning for exploiting water sources (surface and underground), and the irrigation system still needs to ensure water supply for aquaculture. It needs to pay attention to the wastewater treatment solution from aquaculture ponds.

+ Safety management of dams still needs to be improved: there are still many dams, tiny dams at risk of unsafety, and community organizations for safe control of small dams have yet to be established.

2.4. Reason

Objective reasons:

+ Effects of climate change, adverse impacts on irrigation systems

- Irrigation work is currently facing many risks related to weather and climate. Managing and exploiting irrigation works can be significantly affected by droughts, floods, saltwater intrusion caused by climate change, and sea level rise.
- Impacts of climate change, adverse effects of development, extreme weather and climate phenomena, threats to dam safety, and increased flood risk for downstream areas, drought, and saltwater intrusion will become increasingly severe. The flow distribution during the year is unfavorable; the water level of rivers tends to decrease gradually in the dry season but rises in the flood season, making irrigation difficult. Severe natural disasters such as flash floods, floods, and landslides always occur and destroy small irrigation works.

Unfavorable weather and water sources are the leading causes of drought and saltwater intrusion. According to the report of the Ministry of Agriculture and Rural Development on drought and salinity intrusion in the Central and Central Highlands regions, the rainy season in 2012 ended 1-1.5 months earlier than usual; the total annual rainfall is 20-30% short of the average of many years; water levels and flows in rivers and streams are in short supply compared to the standard of many years by 20-60%; Groundwater level is 1-2 m lower than usual, especially the Central Highlands is even 2-3m lower (MARD, 2013).

For more than four months, from the end of 2014 to April 2015, there was no rain in most areas of Ninh Thuan province; There was only a little rain on the morning of April 13, 2015. As of April 2015, the total capacity of reservoirs in the whole province was only 9.3%, compared to 31.3% in the same period in 2014 (Ninh Thuan Hydrometeorological Center, 2015).

Due to the lack of rain, the river's water level and flow volume decreased, so many estuaries in the central region suffered from saline intrusion into the interior, with a salty water line of 1g/liter in many places up to 20-30 km.

+ Adverse impacts of socio-economic development (decreased forest quality, development of upstream reservoirs, sand mining, and subsidence in downstream areas; urban infrastructure development, industry, traffic impedes flood drainage...) adversely affects the system of irrigation works, especially the water intake system along significant rivers across the country, the irrigation system in the Mekong Delta.

+ The process of urbanization and industrialization requires higher irrigation requirements; drainage requirements in many areas have increased much compared to the past, demand for water for daily life and industry from the irrigation works system has increased, and the level of safety assurance has increased. The lack of irrigation leads to limited regulation between the rainy and dry seasons.

+ The organization of small and fragmented agricultural production with low production efficiency makes farmers pay little attention to irrigation.

Subjective causes

- + Investment in construction and management, and exploitation of irrigation works still has many shortcomings
- Lack of centralized and synchronous investment to serve multiple purposes, and the situation of spreading evenly, so irrigation works have not been built synchronously

and entirely to the field, and equipment for exploitation management needs a more severe soul.

- Unplanned water use sectors have caused conflicts among water users.
- + Local irrigation management has not promoted the role of the subject and decision of the people, the active participation of local authorities
- Management and exploitation of irrigation works are still mainly implemented according to the subsidy mechanism, in the form of planning assignment, according to the allocation-payment mechanism, which is not associated with the quantity and quality of products, so the business accounting The economy is only a formality, causing stagnation and weakness in the management and exploitation of irrigation works.
- Lack of mechanisms and policies to motivate people to participate in the construction, management, and exploitation of in-field irrigation works.
- The establishment and operation of grassroots irrigation organizations are still heavily imposed, needing more people's active participation. This is the most fundamental reason why many organizations are unsustainable.
- The current inadequate organizational model and management mechanism has limited the participation of all economic sectors and beneficiaries in managing and exploiting irrigation works. Organizations of other economic sectors, especially the people, have yet to be given the conditions and mechanisms to participate.
- + Science and technology have not kept up with production requirements, lack of motivation to apply science and technology to production, and limited human resources

Although science and technology have received a lot of attention and investment with domestic and international resources, their application and effectiveness are limited:

- Science and technology have not closely followed or correctly forecasted actual needs and are slow to apply advanced technologies in forecasting drought, waterlogging, saltwater intrusion, and decision-making support in natural disaster prevention and control; resources are distributed, spread, technological capacity is not enhanced, not accepted by the production unit.
- The number of scientific and technological projects with results applied to production could be much higher (20-30%) or only used in a narrow range, with no significant impact on irrigation development.
- The effectiveness of international cooperation in applying and learning international experiences on managing and exploiting irrigation works still needs to be higher.
- The study of mechanisms and policies to create motivation, innovate the management of exploitation, and transfer scientific and technical advances in the management and operation of irrigation works has not been given due attention, especially technical skills—Economical use of water.
- Advanced water-saving irrigation technology, although it has many outstanding advantages compared to traditional ones, the application of water-saving irrigation technology still needs to be improved. The reason is that the approach is not synchronized, there is a lack of planning associated with water-saving irrigation, and the participation of businesses is still limited; Mechanisms and policies to support farmers and businesses to promote the application of water-saving irrigation technology have not yet created a motivation; Information and communication on water-saving irrigation solutions and technology transfer are still lacking and weak.

+ Awareness of exploitation management and protection of irrigation works is still limited

- The awareness of some management leaders and people is incorrect and not enough about the current policies in management, exploitation, and protection of irrigation works, especially the exemption and reduction of irrigation fees.
- The ideology of dependence on the State is still heavy, attaching great importance to the issue of investment in construction, neglecting management, failing to arouse and mobilize the strength of the whole people and the entire society to participate in construction, management, exploitation, and protection of irrigation works.
- Public awareness raising has yet to be given due attention.

3. Actual situation of the development of irrigation system for aquaculture in Vietnam

Up to now, the total aquaculture area of the country has more than 900 thousand hectares; the domestic aquaculture and fishing output has reached 1.34 million tons, nearly doubled compared to 1988, which was the time before the Prime Minister's Decision 224/1999/QD-TTg dated December 8, 1999, approving the Aquaculture Program.

Implement Resolution 09/NQ-CP dated June 15, 2000, of the Government on "several policies on economic restructuring and consumption of agricultural products"; Many localities throughout the country have conducted land planning, rearranged crops and adopted animals, implemented technical measures and invested in the construction of irrigation works to serve the restructuring of agricultural production. In the direction of efficiency, it was especially converting low-yielding and precarious rice land to aquaculture.

As a result, aquaculture has grown enormously in scale, productivity, and quality, forming several commodity production areas. Most of the aquaculture area has applied diverse, abundant, and high-income farming models and methods; the average production value of shrimp farming is 150-340 million VND/ha/year. The number of models has reached 700-800 million VND/ha/year; models of fish and shrimp farming on the foot of rice fields in the provinces of Bac Ninh, Hung Yen, Nam Dinh, An Giang, Dong Thap,... the average income is also two to five times higher than that of rice cultivation. The number of households earning income from aquaculture has also increased significantly, contributing to hunger eradication, poverty alleviation, and legitimate enrichment for tens of thousands of farming households in different regions.

However, aquaculture is still developing spontaneously, according to the "movement." At the same time, the planning has not been adjusted; the destruction of mangrove forests for shrimp farming, the destruction of coastal protection forests for shrimp farming on the sand, or Bringing saltwater into the planned "certification" for shrimp and fish farming still occurs, leading to water pollution, shrimp and fish deaths, and heavy losses to producers. In addition, it also has a direct impact on the instability of raw material production and, at the same time, significantly affects the quality of exported products in increasingly strict markets, the risk of not ensuring the target. The export target of the seafood industry right in 2005 and by 2010 will appear clearly unless timely measures are taken.

The main reason for the above situation is the lack of a rational and stable master plan for production and irrigation and a separate irrigation system for aquaculture. In addition, the

assurance of services on irrigation, seed, science and technology transfer, etc., has yet to keep pace with the actual development situation. On the other hand, capital for investment in irrigation works for fisheries is still facing many difficulties; the coordination between sectors and localities in restructuring production is not tight, and the fisheries sector has no function. State management of irrigation is complicated to develop technical solutions and solve water for each farming area, each specific project.

The basic requirements of the irrigation system for aquaculture must first ensure that there is a clean water source, a treatment system, and a regulation of water supply according to the requirements for each farming area, each culture object with the following criteria: appropriate standards and indicators; has an active and controlled drainage system, warns the water environment according to a rigorous process...

All of the above requirements must be designed and built into a complete system, proactively regulating and controlling; Only then can we ensure that water is the top priority for stable and sustainable aquaculture.

Over time, the planning, design, and construction of irrigation systems for aquaculture in some places have made progress, approaching and proposing appropriate water control procedures. In some aquaculture areas, significant investments have been made in water supply, treatment, and drainage systems, contributing to increased productivity and output.

However, the planning and construction of irrigation for fisheries still have many limitations, emerging as a lack of detailed planning and design suitable for each object and aquaculture area, lack of synchronous and complete investment, the status of using the same water supply and drainage lines, alternating between aquaculture areas and crops, between saltwater aquaculture and freshwater farming areas, or salty,...

Other infrastructures (such as electricity, internal traffic, barrier), and the control and warning of water pollution levels, etc., have yet to be given due attention; the planning, construction design, and appraisal must be of better quality. On the other hand, the construction of irrigation works in service of fisheries mainly relies on budget capital, and the contributions of both farmers and businesses in many places are still very modest; Therefore, most irrigation works for aquaculture lack investment capital, construction is lengthy, inconsistent and does not guarantee the quality required by each culture object and culture area.

4. Solutions

To ensure the sustainable development of aquaculture, close and synchronous coordination is required in the construction and construction of a complete irrigation system for each farming area and management solutions, from planning to construction and fundamentally organizing irrigation management in each locality and sub-region. I'd like to point out that critical solutions need to be directed and implemented in the coming time.

Firstly, soon complete the review and adjustment of land use planning for agriculture, forestry, fishery, in general, and aquaculture land in particular, in the spirit of central resolutions on socio-economic development of each region and region and Decision No. 150/2005/QD-TTg dated May 20, 2005, on "approving the master plan on restructuring agricultural, forestry and fishery production throughout the country to 2010 with a vision to 2020 (in which the land plan for aquaculture is 1.44 million ha).

The adjustment of the planning must be based on: investigation, analysis, and synthesis assessment of potential and current land use; clearly define orientations, objectives and rationally allocate land funds for the development needs of each sector and field and stabilize the land use planning period according to Decree No. 68/2001/ND-CP dated 1- 1. October 2001 of the Government on "land use planning and plans" and the spirit of the Government's Resolution 09/2000/NQ-CP on restructuring production. Avoid the change of targets and deadlines on land use planning as much as possible, affecting the planning and construction of irrigation works in all branches.

Secondly, based on the land use planning approved by the competent authority, adjust the planning and design of irrigation to the land use objectives of each locality, including separate planning on the irrigation system for aquaculture.

In the planning and designing of irrigation for aquaculture areas, it is necessary to make the most of already built works, supplement and complete the water supply and drainage systems, and other related jobs. Suitable for each species and farming area. Solve little problems and not allow alternating between aquaculture and crops, between freshwater or brackish water culture areas; integrated use saves water resources.

Thirdly, improve the quality of planning, design, and appraisal by attaching the long-term responsibilities of planning, design, and construction agencies of irrigation systems for aquaculture and other construction projects and other projects. The Government has clear regulations on the assignment and coordination of branches and localities in state management of irrigation works in aquaculture service.

Fourthly, have the plan to mobilize capital for the synchronous and complete construction of each irrigation project in service of aquaculture in the direction of expanding socialization; spend higher budget capital for structure and support economic sectors to build irrigation works according to decentralization; prioritizing money for essential investigation, planning and design of irrigation systems for agriculture and aquaculture. Develop regulations on the management of aquaculture areas after investment.

Fifthly, strengthen guidance and support for producers to access science and technology in farming and post-harvest technology, closely combine with production organizations, and form production models, especially cooperatives. There are regular direction, inspection, and supervision by state management agencies and authorities at all levels, especially the fisheries sector, in the synchronous use of economic, technical, and management measures in the region feed. Pay special attention to efforts to use, protect and improve land and water and protect the ecological environment, ensuring sustainable aquaculture development.

References

- [1]. Nguyen Quang Kim, Tang Duc Thang and Pham Duc Nghia (2005), Branch project report: "Dynamics of water resources in Vam Co river and surrounding areas," State-level project "Study on changes in water resources and environment for sustainable development of Vam Co river basin," 2005.
- [2]. Nguyen An Nien (1997), "On a problem of determining the origin of water masses (application to the Mekong Delta," Collection of Scientific Research Results, Southern Institute of Irrigation Science, Agricultural Publishing House.
- [3]. Nguyen An Nien and Tang Duc Thang (2002), "Irrigation for the development of aquaculture in the transition zone in the southern provinces - Approaches to sustainable

- development," Anthology of Scientific Reports. Studied at the National Conference "Scientific Research for Aquaculture in the Southern Provinces," 2002.
- [4]. Nguyen An Nien and Tang Duc Thang (2003), "Calculation of water source components - a new versatile tool for integrated management of water resources and the environment," Collection of scientific research results from the Institute of Regional Irrigation Sciences South 2003.
- [5]. Nguyen An Nien, Tang Duc Thang, and Nguyen Anh Duc (2003), "Water source composition, its age and calculation of substances with variable concentrations from water composition," Collection of scientific research results from the Institute of Water Science. Southern interests 2003.
- [6]. Nguyen An Nien and Tang Duc Thang (2004), "New developments in the theory of transmission of water resources components and their application expansion," Collection of Scientific Research Results of Southern Institute of Irrigation Science 2004.
- [7]. Nguyen An Nien, Tang Duc Thang and Ho Trong Tien (2004), "Age of water sources and space changes," Collection of Scientific Research Results of Southern Institute of Irrigation Science 2004.
- [8]. Tang Duc Thang (2002), "Research on irrigation systems affected by many water sources - Application examples for the Mekong Delta and the Southeast," Ph.D. thesis.
- [9]. Tang Duc Thang (2005), "Application of the problem of mass transmission of stored water to improve the design quality and efficient operation of river and canal systems and irrigation systems," Journal of Agriculture and Rural Development, No. 15/2005.
- [ten]. Tang Duc Thang (2005), "A method of studying stored water in river and canal systems," Journal of Agriculture and Rural Development, No. 16/2005.
- [11]. MIKE11 - Uses' Guide.
- [twelfth]. Steven Chapra, "Surface water quality modeling," Mac.GrawHill.
- [13]. Nguyen An Nien and Tang Duc Thang (2000), Computation of different derivative flood water components in Mekong Data, Proc. of International European - Asian Workshop ECOSYSTEM&FLOOD 2000, Hanoi, Vietnam.
- [14]. Nguyen An Nien, Tang Duc Thang (2000), "Computation of Mass-Transmission by a Forced-Mixed Model (One Dimensional Problem)," International Colloquium in Mechanics Solid, Fluids and Structures and Interaction, Nha Trang, Vietnam.
- [15]. Nguyen An Nien and Tang Duc Thang (2005), Water Source Computation, New Development, and widening Application, Proc. of International Symposium on Sustainable Development in the Mekong River Basin, Ho Chi Minh City, October 2005, Japan Science and Technology.